MODELING INTERJURISDICTIONAL TAX COMPETITION IN A FEDERAL SYSTEM

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Abstract

Interjurisdictional tax competition is a controversial theme with few empirical studies in spite of the great advance in the theoretical debate of the last decades. In order to link the theoretical issues with empirical tools and results, this paper uses an interregional general equilibrium model to evaluate the welfare effects of an experimental game of tax competition between two regional governments of the Brazilian economy. The results suggest that interjurisdictional tax competition is a race-to-the-bottom but this outcome is welfare-improving at the Nash equilibrium. Also is observed that the vertical linkages of the Brazilian fiscal federalism play an important role on the welfare effects of interjurisdictional tax competition.

Key-words: tax competition, fiscal federalism and interregional CGE model.

Resumo

A discussão sobre competição tributária interjurisdicional é bastante polêmica e há uma lacuna de estudos empíricos sobre seus efeitos, embora tenha ocorrido significativo avanço no debate teórico nas últimas décadas. No sentido de contribuir para integrar a discussão teórica com instrumentos de análise empírica, o presente trabalho utiliza um modelo inter-regional de equilíbrio geral computável para avaliar os efeitos de bem-estar decorrentes de um jogo experimental de competição tributária entre dois governos regionais da economia brasileira. A simulação mostrou que a competição tributária gera um equilíbrio de Nash do tipo *race-to-the-bottom*, mas este equilíbrio é *welfare-improving*. Também foi constatado que as relações verticais subjacentes ao federalismo fiscal brasileiro têm um papel importante na explicação dos efeitos de bem-estar da competição tributária interjurisdicional.

Palavras-chave: competição tributária, federalismo fiscal e modelo CGE inter-regional.

JEL: H39, H73, R13.

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1. Introduction

The theoretical issues on the effects of interjurisdictional tax competition have grown since the seminal work of Tiebout (1956) and there are controversial positions about its welfare effects. On the one hand, theories based on the view of governments exclusively as benevolent agents shown that tax competition is inefficient and produces a suboptimal Nash equilibrium (Mintz and Tulkens, 1986; Zodrow and Mieszkowski, 1986; Wildasin, 1988; Burbdige and Myers, 1994; Cadarelli, Taugourdeau and Vidal, 2002). On the other hand, theories based on the view of governments as a Leviathan agent suggest that tax competition can produce an efficient equilibrium and it works like

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an effective mechanism to refrain the governments' predatory action on the society (Rauscher, 1998; Cassette, Jayet and Paty, 2005).

In spite of the great advance in the theoretical studies, few empirical analyses have been carried out in order to evaluate the welfare effects of interjurisdictional tax competition. An exception is the work of Mendoza and Tesar (2003), where the welfare effects of capital tax competition are analyzed through a two-country dynamic general equilibrium model building based on the neoclassical-growth model. The simulation results conducted by the authors showed that capital tax competition is race-to-the-bottom when consumption tax rates are adjusted to guarantee budget balance but this outcome is welfare improving, contrary to benevolent-base theories.

In fact, the effects of the interjurisdictional tax competition in the real word depend of empirical characteristics associated with the economic system in focus such as the level of regional interdependence between the economies given by the comercial flows of goods and the fiscal linkages between different levels of governments if the competition game takes place into a federal system. This paper proposes to evaluate the welfare effects of the interjurisdictional tax competition using a CGE model calibrated for an economic system where regional governments compete for investments. We assumes that the federal (central) government does not act strategically, but the effects of regional tax competition on the federal tax base has a important role because of the hard vertical linkages imposed by constitutional rules. Taking into account the vertical linkages between the governments is particularly important for the Brazilian federal system because the 1988 Constitution deepened the fiscal transfers from federal government to regional governments. The federal transfers to the regions rose from 10% to 21.5% of the income and indirect tax revenue collected by the federal government.

The paper builds on the B-MARIA-RS, an interregional CGE model calibrated for two regions of the Brazilian economy, Rio Grande do Sul and Rest of Brazil. CGE models are interesting and promising tools to evaluate interjurisdictional tax competition as it incorporates important general equilibrium effects in the analysis and, contrary to econometric studies, it can focus on actual welfare estimates instead of focusing on revenues or fiscal budgets only. The simulation is implemented assuming the regional governments engage in a non cooperative game where the indirect tax rate on manufacturing goods are strategies used to influence allocations of the productive factors (capital and labor). The vertical linkages of the Brazilian federal system are fully modeled in the B-MARIA-RS model.

The Rio Grande do Sul state is the fourth state economy in the country as well as one of the top human development indices in the country, with a diversified manufacturing structure and significant openness to the regional and international markets. The Brazilian case is an interesting one as its sophisticated fiscal federalism institutions (Shah, 1991) that nevertheless shares common problems with other systems in Latin American countries, such as Argentina and Colombia (Tomasi et al., 2001).

The remainder of the paper is organized in four sections. First, after this introduction, the B-MARIA-RS model is presented focusing on its theoretical economic structure and describing the organization of the public finance account by government level and its linkages. The section three presents the modeling strategy adopted to implement the simulation of non cooperative game between the regional governments and the main results are discussed in the following section. The final remarks follow in the last section in an attempt to evaluate our findings and put then in perspective, considering their extension and limitations.

2. The B-MARIA-RS model

B-MARIA-RS (*Brazilian Multisectoral and Regional/Interregional Analysis – Rio Grande do Sul*) is an interregional computable general equilibrium model developed for the analysis of the economy of Rio Grande do Sul and of Brazil. Its theoretical framework is similar to the B-MARIA model (Haddad, 1999) and follows the Australian tradition of general equilibrium models.[1]

The B-MARIA-RS model divides the Brazilian economy into two regions, Rio Grande do Sul and Rest of Brazil, and identifies a single foreign market (Rest of the World). The calibration data are those for 1998, and 25 productive sectors and investment goods are specified for each region. The productive sectors use two local primary factors (capital and labor). The final demand consists of household consumption, investment, exports, and regional and federal government consumption. The regional governments are sources of exclusively local demands and expenditure, comprising the state and municipal levels of public administration in each region. The whole model contains 60,323 equations and 1,475 exogenous variables.[2]

The main innovation in the B-MARIA-RS model is the detailed treatment of public finances that recognizes the horizontal and vertical linkages between the Brazilian governments. As will be described below, this modification allows introducing alternative closures for the governments regarding public finance policies. The core module of the model consists of equation blocks that determine the relationship between supply and demand, derived from optimization theories, and market equilibrium conditions. The indirect taxes at the core of the model are decomposed in order to separate the state indirect tax from the other federal and municipal indirect taxes. In addition, several regional and national aggregates are defined, such as level of aggregate employment, balance of trade and price indices. Next, we present the main theoretical aspects of the model. Other definitions in the model include tax rates, basic prices, and purchase prices of commodities, tax revenues, margins, components of the gross domestic product (GDP) and gross regional product (GRP), regional and national price indices, factor prices, aggregate employment and money wage settings. The functional forms of the main groups of equations of the interregional CGE core are presented in the Appendix together with the definition of the main groups of variables, parameters and coefficients.

Production technology

Figure 1 illustrates the production technology encountered in the B-MARIA-RS model, a usual specification in regional models. This specification defines three levels of optimization for the productive process of firms. The dashed lines indicate the functional forms specified in each stage. Fixed proportion combinations of intermediate inputs and primary factors are assumed at the first level, through the Leontief specification. The second level involves substitution between domestically produced and imported inputs on one side, and substitution between capital and labor on the other side. A constant elasticity substitution (CES) function is used for the combination of inputs and primary factors. At the third level, bundles of domestically produced and imported intermediate inputs are formed as combinations of inputs from different sources. Again, a CES function is used to combine goods from different sources.

The use of CES functions in the production technology implies the adoption of the so-called Armington assumption (Armington, 1969) for product differentiation. This hypothesis regards goods from different sources as imperfect substitutes. For instance, agricultural and livestock products from Rio Grande do Sul are different from the agricultural and livestock products from the Rest of Brazil with regard to their use in the productive process (third level in Figure 1). This

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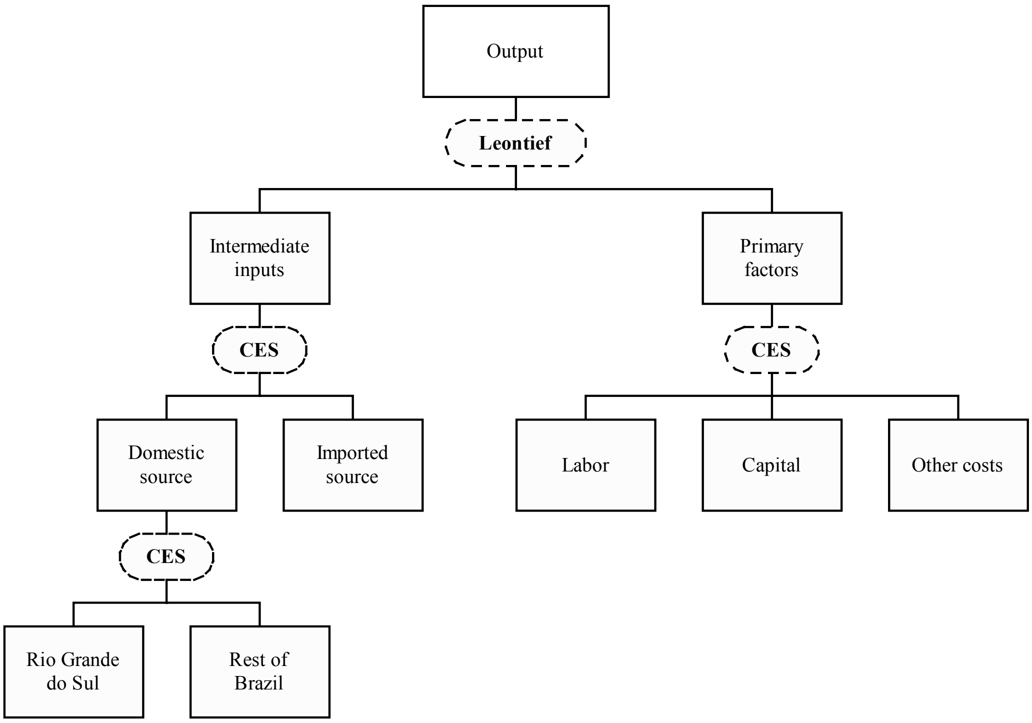
[1] Following this tradition, the models use the Johansen approach, where the mathematical framework is represented by a set of linearized equations and the solutions are obtained as growth rates. In the Brazilian economy, the PAPA (Guilhoto, 1995), EFES (Haddad e Domingues, 2001) and EFES-IT (Haddad *et al.*, 2001; 2002) models, among others, use this approach.

[2] The full description of the model is available in Porsse (2005). The full version for tests and evaluation is available from the authors upon request. This model can be implemented in the demo version of the GEMPACK program (*www.monash.edu.au/policy/gpdemo.htm*).

treatment permits the model to exhibit non-specialized intrasectoral market patterns, an important empirical regularity described in the literature.[3]

Figure 1. Nested Structure of Regional Production Technology



Household demand

Each region has a group of representative households, which buy domestic goods (either locally produced or from other regions) and imported goods. The specification of household demand, in each region, is based on a CES/linear expenditure system (LES) preference function. The demand equations are derived from a utility maximization problem, whose solution follows hierarchical steps, similar to the ones shown in Figure 1. At the bottom level, substitution occurs across different domestic and imported sources of supply. At the subsequent upper level, substitution occurs between domestic composite and imported goods. The utility derived from the consumption of domestic and imported composite goods is maximized according to a Stone-Geary utility function. This specification gives rise to the linear expenditure system (LES), in which the expenditure share above the subsistence level for each good represents a constant proportion of the total subsistence expenditure of each regional household.[4]

Demand for Investment Goods

Investors are a category of use of final demand, and are held responsible for capital formation in each regional sector. They choose the inputs used in the capital formation process through cost minimization using a hierarchically structured technology. This technology is similar to the production technology, with some adaptations. As in the production technology, the capital good is

[3] For product differentiation in the world market and CGE models, see De Melo and Robinson (1989). The behavior of several classes of CES functions is analyzed in Perroni and Rutherford (1995).

[4] For the parameters necessary for the calibration of this specification, see Dixon *et al.* (1982). The LES specification is non-homothetic, such that the increase in the household expenditure (income) causes changes in the share of goods in overall expenditure, *ceteris paribus*.

produced by domestic and imported inputs. At the third level, an aggregate bundle of intermediate goods (domestic and imported) is formed as the combination of inputs from different sources. A CES function is used in the combination of goods from different sources. Differently from the production technology, primary factors are not used directly as input for capital formation, but used indirectly through inputs in sectoral production, especially in the construction sector. The level of regional investment in capital goods per sector is determined by the capital accumulation block.

Exports and Government Demand

All exported goods have downward sloping demand curves for their own prices in the world market. A vector of elasticity defines the response of foreign demand to changes in the FOB price of regional exports.

The government demand for public goods is based on the isolation of the consumption of public goods by the regional and federal governments, obtained from the input-output matrix. However, productive activities carried out by the public sector cannot be dissociated from those performed by the private sector. Thus, the government's entrepreneurial behavior is dictated by the same cost minimization assumptions adopted by the private sector. This hypothesis may be considered more appropriate, at first, for the Brazilian economy, since the privatization process implemented in the 1990s substantially reduced the participation of the government in the productive sector (Haddad, 1999). Public goods consumption is set to maintain a constant proportion with 1) regional private consumption, in the case of regional governments, and 2) with national private consumption, in the case of the federal government.

Capital Accumulation and Investment

Capital stock and investment relationships are defined in this module. There are two comparative static versions for the model that allow its use in short-run and long-run simulations. The use of the comparative statics model implies no fixed relationship between capital and investment; this relationship is selected on the basis of the requirements of the specific simulation. For example, in typical long-run comparative static simulations, growth of investment and capital is assumed to be identical (see Peter *et al.*, 1996). Some qualifications are necessary for the specification of capital formation and investment in the model. As discussed in Dixon *et al.* (1982), the modeling of these components is basically concerned with how investment expenditures are allocated both per sector and per region, and not with the aggregate private investment in construction, machinery and equipment. On top of that, the temporal conception of investment used is not associated with a precise timetable; as we do not focus on the investment expansion path over time. Therefore, the main concern regarding the investment modeling is to capture the effects of the shocks on the allocation of current investment expenditure across sectors and regions.

Labor Market and Regional Migration

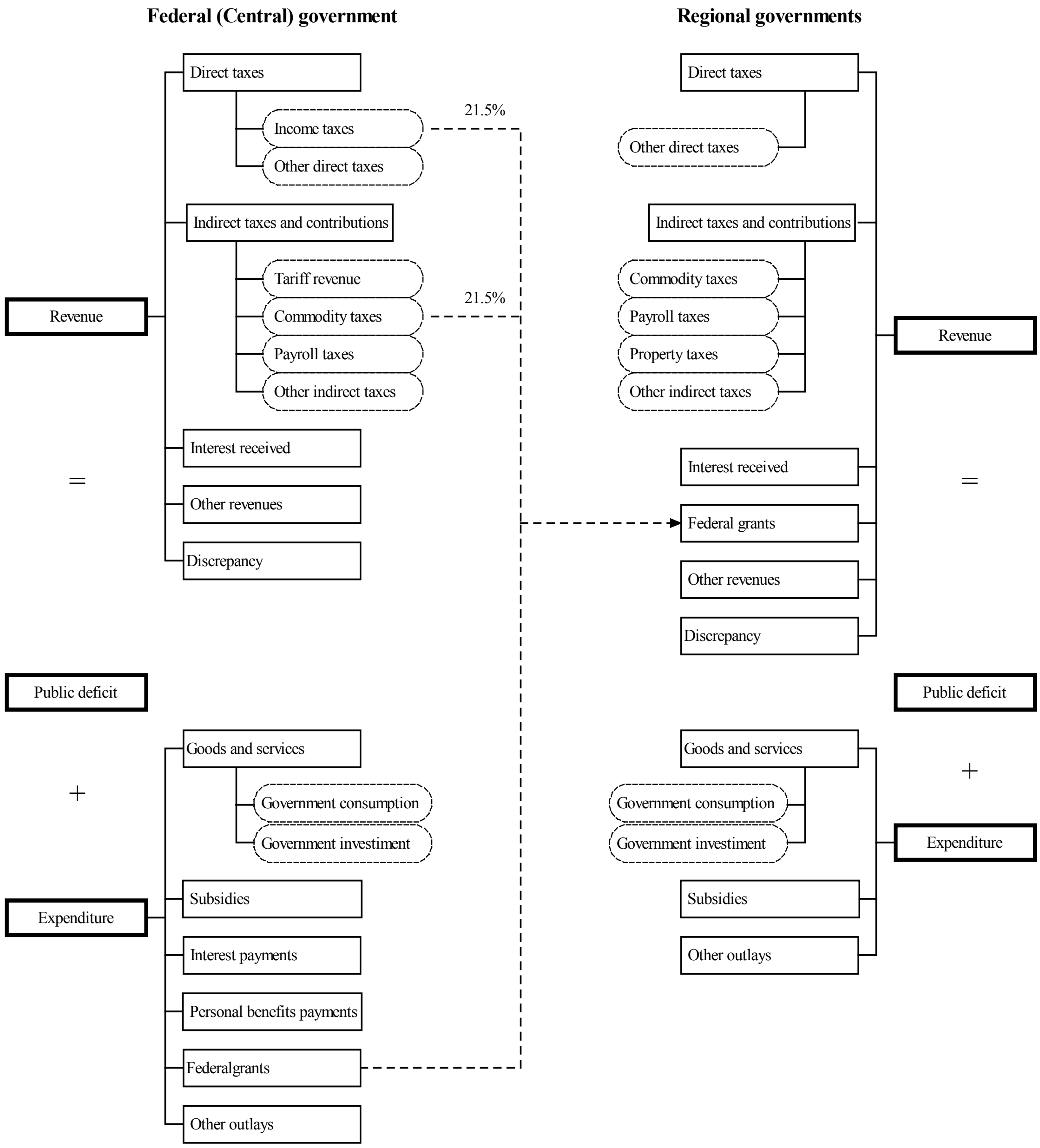
In this module, the population in each region is defined exogenously through the interaction of demographic and interregional migration variables, and there is also a connection between regional population and labor supply. Given the specification of the labor market, labor supply can be determined by interregional wage differentials or by regional unemployment rates, along with demographic variables, often defined exogenously. In sum, both labor supply and wage differentials may determine unemployment rates or, alternatively, labor supply and unemployment rates will determine wage differentials.

Public finance module

The public finance module incorporates equations determining the gross regional product for each region, through the decomposition and modeling of its components, on both the expenditure and income sides. The budget constraints of the regional and federal governments also are defined, as well as the aggregate household consumption functions in each region (disaggregated by the main sources of income and by the respective tax duties).

Figure 2 describes the main characteristics of the government's budget and the fiscal linkages between the central and regional governments modeled in the B-MARIA-RS model in accordance with the Brazilian federalism. The income taxes and the contributions (other indirect taxes) are the most important source of revenue for the central government of Brazil while the indirect commodity tax (an excise tax collected on goods and services transactions by the origin principle) is the main source of revenue for the regional governments. The Brazilian constitutional rules imposes a hard vertical linkage between governments since 21.5% of the income and commodity taxes collected by the central government should be transferred to the regional governments.

Figure 2. Government's budget and fiscal linkages between Brazilian governments



Closures

The B-MARIA-RS model can be used for short-run and long-run comparative static simulations. The basic distinction between these two types of closure lies in the treatment given to the microeconomic approach to capital stock adjustment. Capital stocks are held fixed in the short run, whereas in the long run, policy changes may affect capital stocks in each region.[5] In the short-run closure, in addition to the hypothesis of interindustry and interregional capital immobility, the regional population and labor supply are fixed, the regional wage differentials are constant and the national real wage is fixed. Regional employment is driven by the assumptions on wage rates, which indirectly determine regional unemployment rates. On the demand side, investment expenditures are exogenous – firms cannot reassess investment decisions in the short run. Household consumption follows household disposable income, and government consumption, at both regional and federal levels, is fixed (alternatively, government deficit can be set exogenously, allowing government expenditures to change). Finally, the technology variables are exogenous, given that the model does not present any endogenous growth theory.

In the long-run closure, capital and labor are mobile across sectors and regions. The major differences from the short-run closure lie in the configuration of the labor market and capital accumulation. In the former case, aggregate employment is determined by population growth, labor force participation rates, and the natural rate of unemployment. The distribution of labor force across regions and sectors is totally determined endogenously. Labor is attracted to more competitive sectors in more favored geographical areas. Likewise, capital is directed towards more attractive sectors. This movement keeps the rates of return at their initial levels.

3. Modeling strategy

The simulation is implemented assuming that regional governments play one-shot non- cooperative game where percentage changes in indirect tax rates on manufacturing goods are used as strategies to influence allocations of the productive factors (long run closure), capital and labor, in order to increase the welfare of each regional representative household. We assume percentage changes in indirect tax rates are limited in range due to the electoral implications in the political cycle and institutional issues associated with the fiscal federal system[6]. On the one hand, if the tax rate falls below a certain threshold the welfare losses caused by reductions in public good provision can damage the self interest of the government's authorities since the median voter can remove them in the next election. On the other hand, this can also occur if the tax rate increase above this threshold since the representative household welfare will be worse off due to the increases in the goods prices. Thus, we define *ad hoc* that the range of tax rates changes is 10%, that is, the strategies set of the regional governments is composed by percentage changes in the indirect tax rates limited to the space [-0.10, +0.10][7].

Looking at the Figure 2, this tax competition game implies in changes at the tax revenue collected by the regional governments and a fiscal solvency rule should be defined. Then, we assume the regional governments engage in a non cooperative game concerned with the welfare of the regional representative household and the regional public goods provision (regional government consumption) will be adjusted to maintain the fiscal solvency. This requires building a welfare measure that accounts for the changes in the private and public good consumption in order to evaluate the effects of the tax competition policy. To do so, the game's payoffs is calculated by a

[5] For closures in CGE models, see Dixon and Parmenter (1996) e Dixon *et al*. (1982).

[6] Technically, state indirect taxes cannot be reduced unilaterally by a single state. Such tax reductions need to be unanimously approved in a states' fiscal council (CONFAZ). State tax competition measures are usually implemented by means of tax deferrals with negative interest rates that mimic, in practice, tax rate reductions (Shah, 1991).

[7] Its worth to note that the coefficient of variation of the effective indirect tax rates collected by the regional governments in Brazil between 1988 and 2004 it was 11.2%.

welfare measure that combines additively the Hicksian measure of *relative* equivalent variation with the percentage changes in the provision of regional public goods post-simulation the tax competition policy. The first one is defined as the *percentage change* of the benchmark income the representative household would need in order to get a post-simulation utility under benchmark prices (Bröcker, 1998). Formally, for linear utility functions, the welfare measure used to compute the payoffs of the tax competition game it can be written as[8]:

$$W^r = \theta_U \frac{U^r(1) - U^r(0)}{U^r(0)} + \theta_G \frac{G^r(1) - G^r(0)}{G^r(0)}, \qquad \theta_U + \theta_G = 1 \tag{1}$$

where $U^r(1)$ is the post-shock private consumption utility, $U^r(0)$ is the benchmark private consumption utility, $G^r(1)$ is the post-shock public good consumption, $G^r(0)$ is the benchmark public good consumption and θ_U and θ_G are the private and public goods shares of the representative household consumption. Note that, when the tax competition policy implies reductions in indirect tax rates, the benefits associated with the reduction in basic prices is balanced by the "social" cost of reduction in public good provision because there is less tax revenue to guarantee the fiscal solvency. In other words, due the fiscal solvency rule, the provision of public goods will be as small as the tax collection. Then, $W^r > 0$ if the private consumption gains overcome the public consumption losses.

Now, following Mendoza and Tesar (2003), we can define that the Nash equilibrium of the regional tax competition game is computed as a pair of percentage changes in indirect tax rates (τ^{RS}, τ^{RB}) and the associated payoffs $U(\tau^{RS} \mid \tau^{RB})$ and $U(\tau^{RB} \mid \tau^{RS})$ where:

i) τ^{RS} maximizes $U(\tau^{RS} \mid \tau^{RB})$ given τ^{RB};

ii) τ^{RB} maximizes $U(\tau^{RB} \mid \tau^{RS})$ given τ^{RS};

iii) the payoffs are supported by the prices and allocations corresponding the competitive equilibrium for (τ^{RS}, τ^{RB}) and τ^r (r = RS, RB) $\in$ [-0.10, +0,10];

iv) the fiscal solvency rules are satisfied for the regional and federal governments.

Finally, the simulation also is carried on the hypothesis of exogenous fiscal policy by the federal government. That is, the federal government doesn't have a reaction function in the context of the regional tax competition game, but the vertical linkages still remain because of the constitutional rules. This is an important issue in the Brazilian federalism and alternative closures for the fiscal policy of the federal government can be explored in the future research.

4. Results

A four-step Euler procedure is adopted in the solution the model and the results are reported as percentage changes from the benchmark database. Table 1 presents the payoffs matrix for the regional tax competition game simulated with the B-MARIA-RS model. The results are presented by each 2% changes in the strategies set to evaluate potential non linearities of the payoffs and the slope of the reaction function. The welfare measure shows that the regional representative households are better off when both governments play reductions in the tax rate of the manufacturing goods and are worse off otherwise. The optimal strategies are on the left-right diagonal of the payoffs matrix and the reaction function has a positive slope, that is, the regional governments tend to adopt the same policy choice in such tax competition game. Therefore, the Nash equilibrium is on the left-left corner of the payoffs matrix and corresponds to the usual race-to-the-bottom outcome as advocated by the benevolent-base theories. But the Nash equilibrium is

[8] See Layard and Walters (1978) for details on the equivalent variation concept and Almeida (2003) for derivations of the relative equivalent variation when handling linear utility functions.

welfare-improving like the findings of Mendoza e Tesar (2003). As we will see below, the welfare gains are probably explained by the vertical fiscal linkages because the regional tax competition raises the national tax base and, therefore, the federal transfers to the regional governments compensating own tax revenue reductions.

It is worth to note an interesting result in the payoffs matrix, that is, the majority of the payoffs are positive when the Rio Grande do Sul's government increases the indirect tax rate and the Rest of Brazil's reduce it. The interregional feedback effects and the size asymmetries between the regional economies explain much of this outcome. The final result of the substitution effects associated with the relative prices changes is a composite price of the private goods lower than the benchmark composite prices for both regions. For the Rio Grande do Sul's representative household, the gains of private consumption due to the interregional substitution effect overcome the losses caused by the increase in the local basic prices. This occurs because there is a high integration between these economies. For the Rest of Brazil, the composite price of the goods is lower than the benchmark due to reduction in local prices. The primary factor income rises due the productive re-location effects caused by the mobility of the factors. Also, the Rest of Brazil economy is benefited by the international substitution effects and, since it represents about 92% of the Brazilian economy, its growth has a significant spillover effect on the Rio Grande do Sul.

Table 2 presents the main macroeconomic effects at the Nash equilibrium. The regional tax competition produces a general reduction in the price indexes and the majority of the aggregated demand components have a real positive variation. Both regional economies become more efficient and the output expansion requires a larger demand of primary factors (capital and labor), increasing their earnings. The level of integration between the regional economies raises and there is also a positive effect on the international trade balance because of the substitution effect of imported goods. All the feedback effects of regional tax competition cause an expansion in output and employment for the regions and the whole country. The negative effect in the Rest of Brazil's employment just reveals an adjustment in the regional labor market due to the migration effects.

Only the regional government consumption presents a real reduction because of the fiscal solvency rule. As showed in Table 3, the race-to-the-bottom equilibrium implies a substantial negative variation in indirect commodity tax revenues of the regional governments. The budget balance is achieved by reductions in the regional public good provisions (regional government consumption). But, since the national tax base rises due to the positive feedback effects of regional tax competition, there is a positive effect on the indirect commodity taxes and the income tax collected by the federal government. This effect benefits the regional government budgets through the vertical linkages associated with the constitutional rules and helps to alleviate the reduction pressures on the regional government's revenue and on the regional public goods provision. Otherwise, would be needed a bigger reduction of expenditure side to achieve the regional fiscal solvency. Therefore, the hard vertical linkages contributes to alleviate the adjustment pressures on the regional public goods provision when regional tax competition is active and such specificity of the Brazilian federalism reinforces the welfare improving Nash equilibrium.

Table 1. Payoffs matrix of the interjurisdictional tax competition game

Strategies		Rest of Brazil																					
		-0.10		-0.08		-0.06		-0.04		-0.02		0.00		0.02		0.04		0.06		0.08		0.10	
Rio Grande do Sul	-0.10	3.769	3.856	3.168	3.118	2.571	2.388	1.979	1.664	1.391	0.948	0.807	0.239	0.228	-0.464	-0.348	-1.159	-0.919	-1.848	-1.487	-2.531	-2.050	-3.208
	-0.08	3.600	3.806	3.000	3.068	2.405	2.338	1.814	1.616	1.227	0.900	0.644	0.191	0.066	-0.511	-0.508	-1.207	-1.079	-1.895	-1.645	-2.578	-2.207	-3.254
	-0.06	3.432	3.756	2.834	3.019	2.239	2.289	1.649	1.567	1.064	0.851	0.482	0.143	-0.095	-0.559	-0.668	-1.254	-1.238	-1.942	-1.803	-2.624	-2.364	-3.300
	-0.04	3.265	3.706	2.667	2.970	2.074	2.240	1.486	1.518	0.901	0.803	0.321	0.095	-0.255	-0.606	-0.828	-1.301	-1.396	-1.989	-1.960	-2.670	-2.520	-3.346
	-0.02	3.098	3.656	2.502	2.920	1.910	2.191	1.323	1.470	0.739	0.755	0.160	0.047	-0.415	-0.653	-0.986	-1.348	-1.553	-2.035	-2.116	-2.717	-2.675	-3.392
	0.00	2.933	3.607	2.338	2.871	1.747	2.143	1.160	1.422	0.578	0.707	0.000	0.000	-0.574	-0.701	-1.144	-1.394	-1.710	-2.082	-2.272	-2.763	-2.830	-3.437
	0.02	2.767	3.558	2.174	2.822	1.584	2.094	0.999	1.373	0.418	0.660	-0.159	-0.047	-0.732	-0.748	-1.301	-1.441	-1.866	-2.128	-2.427	-2.809	-2.984	-3.483
	0.04	2.603	3.508	2.010	2.774	1.422	2.046	0.838	1.325	0.258	0.612	-0.318	-0.095	-0.890	-0.794	-1.457	-1.488	-2.021	-2.174	-2.581	-2.855	-3.137	-3.528
	0.06	2.439	3.459	1.848	2.725	1.261	1.998	0.678	1.278	0.099	0.564	-0.476	-0.142	-1.047	-0.841	-1.613	-1.534	-2.176	-2.220	-2.735	-2.900	-3.290	-3.574
	0.08	2.276	3.410	1.686	2.676	1.100	1.949	0.518	1.230	-0.060	0.517	-0.633	-0.189	-1.203	-0.888	-1.768	-1.580	-2.330	-2.266	-2.888	-2.946	-3.442	-3.619
	0.10	2.114	3.362	1.525	2.628	0.940	1.901	0.359	1.182	-0.217	0.470	-0.790	-0.236	-1.358	-0.934	-1.923	-1.627	-2.483	-2.312	-3.040	-2.991	-3.593	-3.664

Source: Calculated by the authors.

Notes: The strategies are percentage changes in indirect tax rate of manufacturing goods adopted by the regional governments. The payoffs by the welfare measure defined in equation (1) and the Nash equilibrium is identified by gray cells.

Table 2. Macro-regional effects at the Nash equilibrium (%)

Variables	Rio Grande do Sul	Rest of Brazil	Brazil
GDP components			
Real household consumption	1.405	1.071	1.094
Real aggregate investment	1.720	1.325	1.350
Real aggregate regional government demand	-2.390	-2.712	-2.206
Real aggregate federal government demand	-	-	-
Interregional export volume	1.273	1.567	-
International export volume	2.063	1.691	1.727
Interregional import volume	1.567	1.273	-
International import volume	0.865	0.611	0.625
Prices			
Consumer price index	-0.516	-0.390	-0.399
Investment price index	-0.502	-0.366	-0.375
Regional government price index	0.578	0.492	0.497
Federal government price index	0.578	0.492	0.496
Interregional export price index	-0.282	-0.171	-
International export price index	-1.198	-0.957	-0.980
Interregional import price index	-0.171	-0.282	-
International import price index	-	-	-
GDP deflator (expenditure side)	-0.505	-0.321	-0.335
Primary factors			
Aggregate payments to capital	1.131	0.929	0.944
Aggregate payments to labor	1.008	0.773	0.791
Aggregate capital stock	1.642	1.305	1.329
Welfare indicators			
REV	4.446	4.744	4.720
Real GDP	0.998	0.731	0.751
Employment	0.218	-0.015	0.002

Source: calculated by the authors.

Table 3. Public finances effects at the Nash equilibrium by level of government (%)

Variables	Governments		
	Rio Grande do Sul	Rest of Brazil	Federal
Government's revenue	-2.010	-2.239	-0.129
Tax revenue	-2.442	-2.390	0.299
Direct taxes	-0.090	-0.084	0.237
Income taxes	-	-	0.352
Other direct taxes	-0.090	-0.084	-0.083
Indirect taxes	-7.882	-5.975	0.752
Tariff revenue	-	-	0.084
Commodity taxes	-9.653	-7.091	4.102
Payroll taxes	0.702	0.555	-0.083
Property taxes	-0.090	-0.084	-
Land taxes	-	-	-
Other indirect taxes	-0.090	-0.084	-0.083
Interests received	-0.090	-0.084	-0.083
Federal transfers	22.101	11.130	-
Other revenues	-0.090	-0.084	-0.083
Discrepancy	-2.404	-2.726	-
Public deficit	-	-	-
Government's expenditure	-2.010	-2.239	-0.129
Expenditures with goods and services	-2.051	-2.322	0.041
Government consumption	-2.404	-2.726	-
Government investment	0.632	0.462	0.545
Personal benefit payments	-0.759	-0.905	-0.887
Subsidies	-7.087	-4.835	-5.020
Interest payments	-0.090	-0.084	-0.083
Federal transfers to regions	-	-	11.903
Other outlays	-2.010	-2.239	-0.129

Source: calculated by the authors.

56. Final remarks

In an empirical perspective, this paper provided important insights for the debate on interjurisdictional tax competition. In accordance with Mendoza and Tesar (2003), the experimental exercise implemented through the B-MARIA-RS model showed the one-shot tax competition game between regional governments can imply a race-to-the-bottom Nash equilibrium on tax rates, but welfare improving. However, while the regional governments indirect tax revenues fall markedly due to the reduction in tax rate at the Nash equilibrium, the federal government revenue is benefited by the growth in national tax base of the direct and indirect taxes. In special case of the Brazilian federalism, the welfare gains of the regional tax competition can be very high since the hard vertical linkages imposed by the constitutional rules allow alleviating the reduction pressures on the regional provision of public goods. In addition, it can be seen that price effects are very important, leading to welfare gains. Focusing only of fiscal issues only lead to a limited and misleading picture of tax competition. The CGE approach allows shifting the focus of the political discourse from public finances to actual household welfare.

These findings suggest that the actual effects of the interjurisdictional tax competition depend on the empirical structure of the economic system in analysis, such as the complementary or competitive relationships between the regional economies and the fiscal environment. The welfare improving outcome founded in this paper probably is associated with the methodological solution employed here, that is, the CGE modeling. Differently of the partial analysis used in many theoretical issues on tax competition, the CGE approach allows to overcome the hypothesis that governments do not evaluate the fiscal externalities into the payoff function. Such hypothesis is very appropriated in a partial context but not in a general equilibrium analysis because all feedback effects are computed in the equilibrium solution. In other words, the payoffs calculated by the CGE model take into account the bi-directional impact of the tax policy changes executed by each regional government. More precisely, the Nash equilibrium is an allocation Pareto optimum.

The analysis of the interjurisdictional tax competition in the context of the Brazilian federal system showed that the fiscal rules matter for the outcome. It was observed that the hard vertical linkage between the governments is an important aspect of the welfare improving equilibrium. While this may be specific to the Brazilian federalism system, it can provide much needed input for fiscal reforms discussions across the region. Also, the simulation was implemented on the hypothesis that fiscal policy of the federal government is exogenous, implying the federal government is not an active player in the tax competition game. But in the last decade, the Brazilian federal government has been making several changes in its fiscal policy in order to raise its role in the economy after the 1988 Constitutional reform promoted a decentralization process. The federal government promoted reductions in the indirect and direct tax rates, compensated by increases in the social contributions. In addition, the rigidity of the governmental expenditure, also implemented by the 1998 Constitutional reform, and the adoption of a Fiscal Responsibility Law in order to maintain the fiscal solvency have imposed hard limits to adjustments in the public expenditures. Then, evaluating the welfare sensitivity of interjurisdictional tax competition by different hypothesis on the behavior of the federal government as an active player and on the rigidity in promote expenditure adjustments by the regional governments seems a prominent issue to be explored in the future research.

67. References

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Appendix

The notational convention uses uppercase letters to represent the levels of the variables and lowercase for their percentage-change representation. Superscripts *(u)*, *u = 0, 1j, 2j, 3, 4, 5, 6*, refer, respectively, to output *(0)* and to the six different regional-specific users of the products identified in the model: producers in sector *j (1j)*, investors in sector *j (2j)*, households *(3)*, purchasers of exports *(4)*, regional governments *(5)* and the Federal government *(6)*; the second superscript identifies the domestic region where the user is located. Inputs are identified by two subscripts: the first takes the values *1, ..., g*, for commodities, *g + 1*, for primary factors, and *g + 2*, for "other costs" (basically, taxes and subsidies on production); the second subscript identifies the source of the input, being it from domestic region *b (1b)* or imported *(2)*, or coming from labor *(1)*, capital *(2)* or land *(3)*. The symbol (•) is employed to indicate a sum over an index.

Equations

(A1) Substitution between products from different regional domestic sources

$$x_{(i(1b))}^{(u)r} = x_{(i(1\bullet))}^{(u)r} - \sigma_{(i)}^{(u)r}\,(p_{(i(1b))}^{(u)r} - \sum_{l \in S^{*}} (V(i,1l,(u),r)/V(i,1\bullet,(u),r)(p_{(i(1l))}^{(u)r}))$$

$i = 1,...,g;\ b = 1,...,q;\ (u) = 3$ and (kj) for $k = 1$ and 2 and $j = 1,...,h; r = 1,...,R$

(A2) Substitution between domestic and imported products

$$x_{(is)}^{(u)r} = x_{(i\bullet)}^{(u)r} - \sigma_{(i)}^{(u)r}\,(p_{(is)}^{(u)r} - \sum_{l=1\bullet,2} (V(i,l,(u),r)/V(i,\bullet,(u),r)(p_{(il)}^{(u)r}))$$

$i = 1,...,g;\ s = 1\bullet$ and 2; $(u) = 3$ and (kj) for $k = 1$ e 2 and $j = 1,...,h; r = 1,...,R$

(A3) Substitution between labor, capital and land

$$x_{(g+1,s)}^{(1j)r} - a_{(g+1,s)}^{(1j)r} = \alpha_{(g+1,s)}^{(1j)r} x_{(g+1\bullet)}^{(1j)r} - \sigma_{(g+1)}^{(1j)r}\{p_{(g+1,s)}^{(1j)r} + a_{(g+1,s)}^{(1j)r}$$
$$- \sum_{l=1,2,3} (V(g+1,l,(1j),r)/V(g+1,\bullet,(1j),r))(p_{(g+1,l)}^{(1j)r} + a_{(g+1,l)}^{(1j)r})\}$$

$j = 1,...,h;\ \ s = 1, 2$ and 3; $r = 1,...,R$

(A4) Intermediate and investment demands for composites commodities and primary factors

$$x_{(i\bullet)}^{(u)r} = \mu_{(i\bullet)}^{(u)r} z^{(u)r} + a_{(i)}^{(u)r}$$

$u = (kj)$ for $k = 1, 2$ and $j = 1,...,h$
if $u = (1j)$ then $i = 1,...,g+2$
if $u = (2j)$ then $i = 1,...,g;$
$r = 1,...,R$

(A5) Household demands for composite commodities

$$V(i,\bullet,(3),r)(p_{(i\bullet)}^{(3)r}+x_{(i\bullet)}^{(3)r})=$$
$$\gamma_{(i)}^{r}P_{(i\bullet)}^{(3)r}Q^{r}(p_{(i\bullet)}^{(3)r}+x_{(i\bullet)}^{(3)r})+\beta_{(i)}^{r}(C^{r}-\sum_{j\in G}\gamma_{(j)}^{r}P_{(i\bullet)}^{(3)r}Q^{r}(p_{(i\bullet)}^{(3)r}+x_{(i\bullet)}^{(3)r}))$$
$i=1,\ldots,g;\ r=1,\ldots,R$

(A6) Composition of output by industries

$$x_{(i1)}^{(0j)r}=z^{(1j)r}+\sigma^{(0j)r}(p_{(i1)}^{(0)r}-\sum_{t\in G}(Y(t,j,r)/Y(\bullet,j,r))p_{(t1)}^{(0)r})$$

$j=1,\ldots,h;\ \ \mathrm{i}=1,\ldots,\mathrm{g};\ r=1,\ldots,R$

(A7) Indirect tax rates

$$t(\tau,i,s,(u)r)=f_{(\tau)}+f_{(\tau i)}+f_{(\tau i)}^{(u)}+f_{(\tau i)}^{(u)r},\quad i=1,\ldots,g;\quad s=1b,2\text{ for }b=1,\ldots,q;\ \tau=1,\ldots,t$$
$$(u)=(3),(4),(5),(6)\text{ and }(kj)\text{ for }k=1,2;\ j=1,\ldots,h$$
$$r=1,\ldots,R$$

(A8) Purchasers' prices related to basic prices, margins (transportation costs) and taxes

$$V(i,s,(u),r)p_{(is)}^{(u)r}=(B(i,s,(u),r)+\sum_{\tau\in T}T(\tau,i,s,(u),r))(p_{(is)}^{(0)}+t(\tau,i,s,u,r))$$
$$+\sum_{m\in G}M(m,i,s,(u),r)p_{(m1)}^{(0)r},$$
$i=1,\ldots,g;\ (u)=(3),(4),(5),(6)$
and (kj) for $k=1,2$ and $j=1,\ldots,h;\ s=1b,2$ for $b=1,\ldots,q$
$r=1,\ldots,R$

(A9) Foreign demands (exports) for domestic goods

$$(x_{(is)}^{(4)r}-fq_{(is)}^{(4)r})=\eta_{(is)}^{r}(p_{(is)}^{(4)r}-e-fp_{(is)}^{(4)r})\ ,\qquad i=1,\ldots,g\ ;\ s=1b,2\text{ for }b=1,\ldots,q;r=1,\ldots,R$$

(A10) Regional governments demands

$$x_{(is)}^{(5)r}=x_{(\bullet\bullet)}^{(3)r}+f_{(is)}^{(5)r}+f^{(5)r}+f^{(5)}\qquad i=1,\ldots,g;\ s=1b,2\text{ for }b=1,\ldots,q;\mathrm{r}=1,\ldots,\mathrm{R}$$

(A11) Regional governments demands

$$x_{(is)}^{(6)r}=x_{(\bullet\bullet)}^{(3)\bullet}+f_{(is)}^{(6)r}+f^{(6)r}+f^{(6)}\qquad i=1,\ldots,g;\ s=1b,2\text{ for }b=1,\ldots,q;\mathrm{r}=1,\ldots,\mathrm{R}$$

(A12) Margins demands for domestic goods

$$x_{(m1)}^{(is)(u)r}=\theta_{(is)}^{(u)r}x_{(is)}^{(u)r}+a_{(m1)}^{(is)(u)r}$$
$m,i=1,\ldots,g;$
$(u)=(3),(4b)$ for $b=1,\ldots,r,(5)$ and (kj) for $k=1,2;$
$j=1,\ldots,h;\ s=1b,2$ for $b=1,\ldots,r;$
$r=1,\ldots,R$

(A13) Demand equals supply for regional domestic commodities

$$\sum_{j \in H} Y(l,j,r) x_{(l1)}^{(0j)r} = \sum_{u \in U} B(l,1,(u),r) x_{(l1)}^{(u)r} + \sum_{i \in G} \sum_{s \in S} \sum_{u \in U} M(l,i,s,(u),r) x_{(l1)}^{(is)(u)r} \qquad l = 1,\ldots,g;\ r = 1,\ldots,R$$

(A14) Regional industry revenue equals industry costs

$$\sum_{l \in G} Y(l,j,r)(p_{(l1)}^{(0)r} + a_{(l1)}^{(0)r}) = \sum_{l \in G^*} \sum_{s \in S} V(l,s,(1j),r)(p_{(ls)}^{(1j)r}), \quad j = 1,\ldots,h;\ r = 1,\ldots,R$$

(A15) Basic price of imported commodities

$$p_{(i(2))}^{(0)} = p_{(i(2))}^{(w)} - e + t_{(i(2))}^{(0)}, \qquad i = 1,\ldots,g$$

(A16) Cost of constructing units of capital for regional industries

$$V(\bullet,\bullet,(2j),r)(p_{(k)}^{(1j)r} - a_{(k)}^{(1j)r}) = \sum_{i \in G} \sum_{s \in S} V(i,s,(2j),r)(p_{(is)}^{(2j)r} + a_{(is)}^{(2j)r}), \quad j = 1,\ldots,h;\ r = 1,\ldots,R$$

(A17) Investment behavior

$$z^{(2j)r} = x_{(g+1,2)}^{(1j)r} + 100 f_{(k)}^{(2j)r}, \qquad j = 1,\ldots,h;\ r = 1,\ldots,R$$

(A18) Capital stock in period T+1 – comparative statics

$$x_{(g+1,2)}^{(1j)r}(1) = x_{(g+1,2)}^{(1j)r} \qquad j = 1,\ldots,h;\ r = 1,\ldots,R$$

(A19) Definition of rates of return to capital

$$r_{(j)}^{r} = Q_{(j)}^{r}(p_{(g+1,2)}^{(1j)r} - p_{(k)}^{(1j)r}), \qquad j = 1,\ldots,h;\ r = 1,\ldots,R$$

(A20) Relation between capital growth and rates of return

$$r_{(j)}^{r} - \omega = \varepsilon_{(j)}^{r}(x_{(g+1,2)}^{(1j)r} - x_{(g+1,2)}^{(\bullet)r}) + f_{(k)}^{r}, \qquad j = 1,\ldots,h;\ r = 1,\ldots,R$$

Other definitions in the CGE core include: revenue from indirect taxes, import volume of commodities, components of regional/national GDP, regional/national price indices, wage settings, definitions of factor prices, and employment aggregates.

Variables

Variable	Index ranges	Description
$x_{(is)}^{(u)r}$	(u) = (3), (4), (5), (6) and (kj) for k = 1, 2 and j = 1,…,h; if (u) = (1j) then i = 1,…,g + 2; if (u) ≠ (1j) then i = 1,…,g; s = 1b, 2 for b = 1,…,q; and i = 1,…,g and s = 1, 2, 3 for i = g+1 r = 1,…,R	Demand by user (u) in region r for good or primary factor (is)
$p_{(is)}^{(u)r}$	(u) = (3), (4), (5), (6) and (kj) for k = 1, 2 and j = 1,…,h; if (u) = (1j) then i = 1,…,g + 2; if (u) ≠ (1j) then i = 1,…,g; s = 1b, 2 for b = 1,…,q; and i = 1,…,g and s = 1, 2, 3 for i = g+1 r = 1,…,R	Price paid by user (u) in region r for good or primary factor (is)
$x_{(i\bullet)}^{(u)r}$	(u) = (3) and (kj) for k = 1, 2 and j = 1, …,h. if (u) = (1j) then i = 1, …,g + 1; if (u) ≠ (1j) then i = 1, …,g r = 1,…,R	Demand for composite good or primary factor i by user (u) in region r
$a_{(g+1,s)}^{(1j)r}$	j = 1, …,h and s = 1, 2, 3 r = 1,…,R	Primary factor saving technological change in region r
$a_{(i)}^{(u)r}$	i = 1,...,g, (u) = (3) and (kj) for k = 1, 2 and j = 1,..., h r = 1,…,R	Technical change related to the use of good i by user (u) in region r
C^r		Total expenditure by regional household in region r
Q^r		Number of households
$z^{(u)r}$	(u) = (kj) for k = 1, 2 and j = 1, …,h r = 1,…,R	Activity levels: current production and investment by industry in region r
$fq_{(is)}^{(4)r}$	i = 1, …,g; s = 1b, 2 for b = 1, …,q r = 1,…,R	Shift (quantity) in foreign demand curves for regional exports
$fp_{(is)}^{(4)r}$	i = 1, …,g; s = 1b, 2 for b = 1, …,q r = 1,…,R	Shift (price) in foreign demand curves for regional exports
e		Exchange rate
$x_{(m1)}^{(is)(u)r}$	m, i = 1,…,g; s = 1b, 2 for b = 1,…,q (u) = (3), (4), (5), (6) and (kj) for k = 1, 2 and j = 1, …,h r = 1,…,R	Demand for commodity (m1) to be used as a margin to facilitate the flow of (is) to (u) in region r
$a_{(m1)}^{(is)(u)r}$	m, i = 1,…,g; s = 1b, 2 for b = 1,…,q (u) = (3), (4), (5), (6) and (kj) for k = 1, 2 and j = 1, …,h r = 1,…,R	Technical change related to the demand for commodity (m1) to be used as a margin to facilitate the flow of (is) to (u) in region r

Variable	Index ranges	Description
$x_{(i1)}^{(0j)r}$	i = 1,…,g; j = 1,…,h r = 1,...,R	Output of domestic good i by industry j
$p_{(is)}^{(0)r}$	i = 1,…,g; s = 1b, 2 for b = 1,…,q r = 1,...,R	Basic price of good i in region r from source s
$p_{(i(2))}^{(w)}$	i = 1,…,g	USD c.i.f. price of imported commodity i
$t_{(i(2))}^{(0)}$	i = 1,…,g	Power of the tariff on imports of i
$t(\tau, i, s, (u)r)$	i = 1,…,g; τ = 1,…,t; s = 1b, 2 for b = 1,…,q (u) = (3), (4), (5), (6) and (kj) for k = 1, 2 and j = 1,…,h r = 1,...,R	Power of the tax τ on sales of commodity (is) to user (u) in region r
$f_{(k)}^{(2j)r}$	j = 1,…,h r = 1,...,R	Regional-industry-specific capital shift terms
$f_{(k)}^{r}$	r = 1,...,R	Capital shift term in region r
$x_{(g+1,2)}^{(1j)r}(1)$	j = 1,…, h r = 1,...,R	Capital stock in industry j in region r at the end of the year, i.e., capital stock available for use in the next year
$p_{(k)}^{(1j)r}$	j = 1,…, h r = 1,...,R	Cost of constructing a unit of capital for industry j in region r
$f_{(\tau)}$	τ = 1,…,t	Shift term allowing uniform percentage changes in the power of tax τ
$f_{(\tau i)}$	τ = 1,…,t; i = 1, …,g	Shift term allowing uniform percentage changes in the power of tax τ on commodity i
$f_{(\tau i)}^{(u)}$	τ = 1,…,t; (u) = (3), (4), (5), (6) and (kj) for k = 1, 2 and j = 1, …, h	Shift term allowing uniform percentage changes in the power of tax τ of commodity i on user (u)
$f_{(\tau i)}^{(u)r}$	τ = 1,…,t; (u) = (3), (4), (5), (6) and (kj) for k = 1, 2 and j = 1, …, h r = 1,…,R	Shift term allowing uniform percentage changes in the power of tax τ of commodity i on user (u) in region r
$f_{(is)}^{(5)r}$	i = 1, …,g; s = 1b, 2 for b = 1,…,q r = 1,…,R	Commodity and source-specific shift term for regional government expenditures in region r
$f^{(5)r}$	r = 1,…,R	Shift term for regional government expenditures in region r
$f^{(5)}$		Shift term for regional government expenditures
$f_{(is)}^{(6)r}$	i = 1, …,g; s = 1b, 2 for b = 1,…,q r = 1,…,R	Commodity and source-specific shift term for Federal government expenditures in region r
$f^{(6)r}$	r = 1,…,R	Shift term for Federal government expenditures in region r
$f^{(6)}$		Shift term for Federal government expenditures
ω		Overall rate of return on capital (short-run)
$r_{(j)}^{r}$	j = 1,...,h r = 1,…,R	Regional-industry-specific rate of return

Parameters, Coefficients and Sets

Symbol	Description
$\sigma^{(u)r}_{(i)}$	Parameter: elasticity of substitution between alternative sources of commodity or factor i for user (u) in region r
$\sigma^{(0j)r}$	Parameter: elasticity of transformation between outputs of different commodities in industry j in region r
$\alpha^{(1j)r}_{(g+1,s)}$	Parameter: returns to scale to individual primary factors in industry j in region r
$\beta^{r}_{(i)}$	Parameter: marginal budget shares in linear expenditure system for commodity i in region r
$\gamma^{r}_{(i)}$	Parameter: subsistence parameter in linear expenditure system for commodity i in region r
$\varepsilon^{r}_{(j)}$	Parameter: sensitivity of capital growth to rates of return of industry j in region r
$\eta^{r}_{(is)}$	Parameter: foreign elasticity of demand for commodity i from region r
$\theta^{(u)r}_{(is)}$	Parameter: scale economies to transportation of commodity (i) produced in region r shipped to user (u) in region r
$\mu^{(u)r}_{(i\bullet)}$	Parameter: returns to scale to primary factors (i = g+1 and u = 1j); otherwise, $\mu^{(u)r}_{(i\bullet)}=1$
$B(i,s,(u),r)$	Input-output flow: basic value of (is) used by (u) in region r
$M(m,i,s,(u),r)$	Input-output flow: basic value of domestic good m used as a margin to facilitate the flow of (is) to (u) in region r
$T(\tau,i,s,(u),r)$	Input-output flow: collection of tax τ on the sale of (is) to (u) in region r
$V(i,s,(u),r)$	Input-output flow: purchasers' value of good or factor i from source s used by user (u) in region r
$Y(i,j,r)$	Input-output flow: basic value of output of domestic good i by industry j from region r
$Q^{r}_{(j)}$	Coefficient: ratio, gross to net rate of return
G	Set: {1,2, …, g}, g is the number of composite goods
G*	Set: {1,2, …, g+1}, g+1 is the number of composite goods and primary factors
H	Set: {1,2, …, h}, h is the number of industries
U	Set: {(3), (4), (5), (6), (k j) for k = 1, 2 and j = 1, …, h}
U*	Set: {(3), (k j) for k = 1, 2 and j = 1, …, h}
S	Set: {1, 2, …, r+1}, r+1 is the number of regions (including foreign)
S*	Set: {1, 2, …,r}, r is the number of domestic regions
T	Set: {1, …, t}, t is the number of indirect taxes